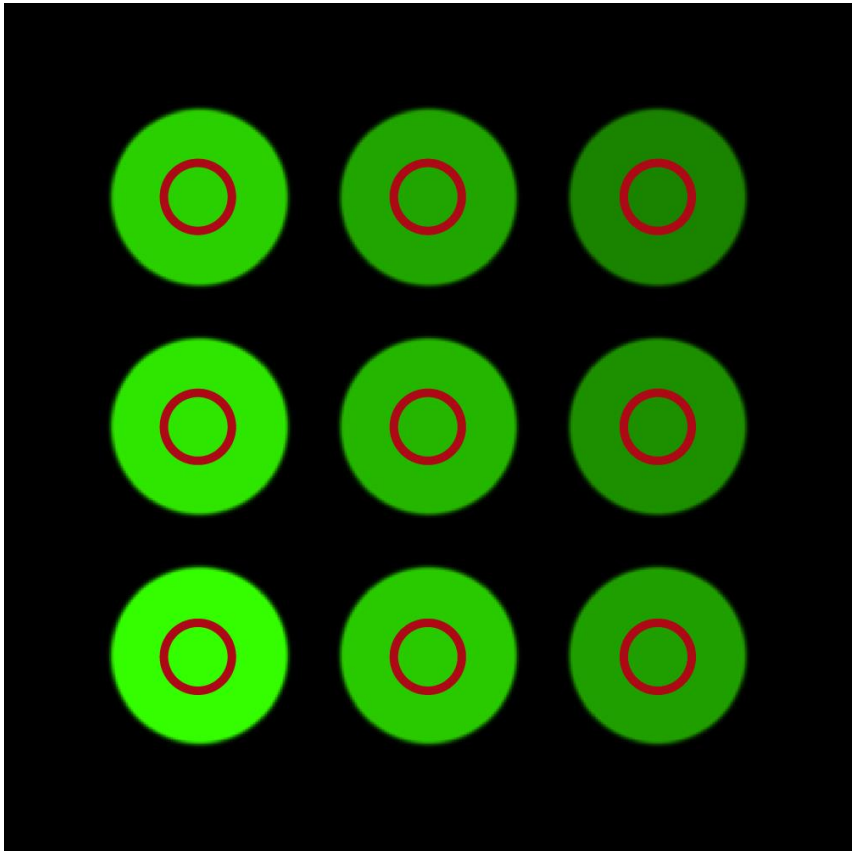
Uniformity Detector in the Waveguide Toolbox

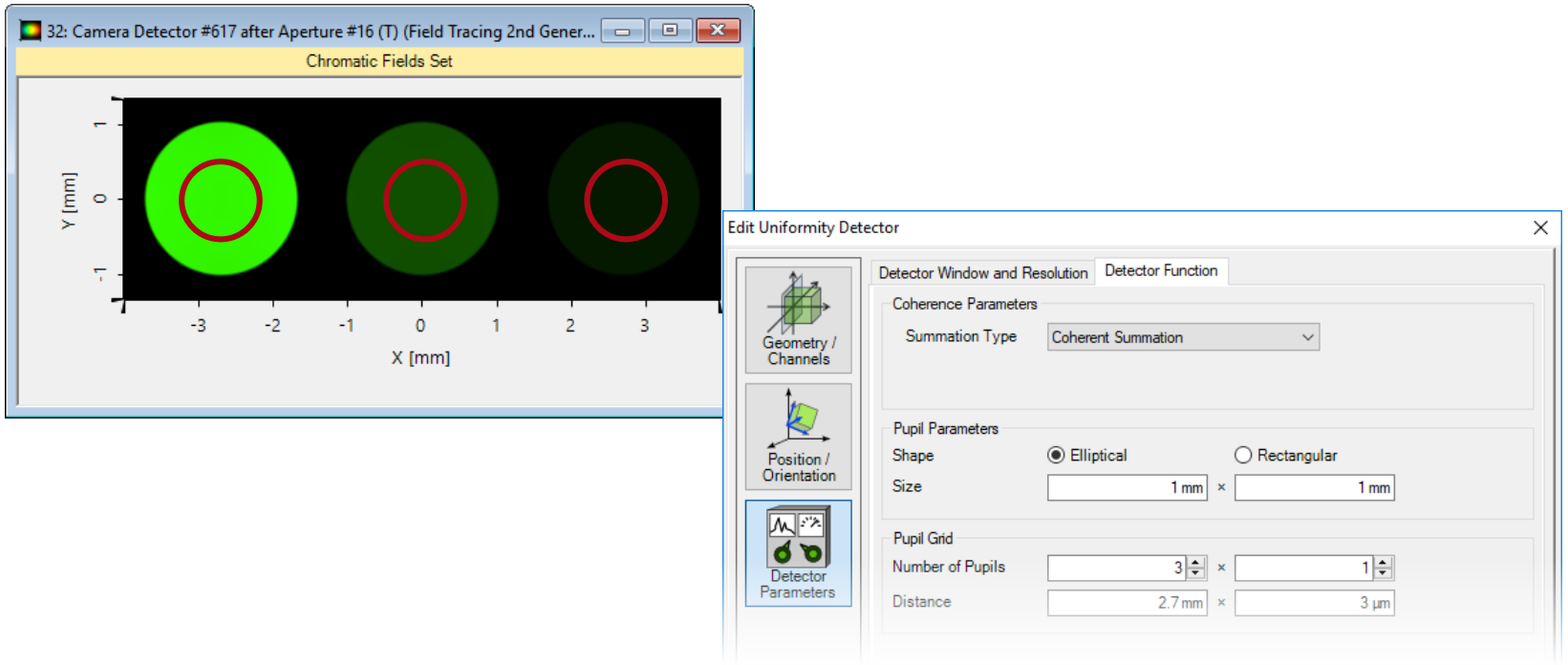
Abstract



In the advanced imaging system, when the exit pupils are extended / repeated, uniformity of the energy of these exit pupils is an important merit function to evaluate the quality of the optical system. Design of such imaging system can be realized with the waveguide toolbox, where a uniformity detector is implemented. The uniformity detector determines the energy uniformity in a series of pupils on an equidistant grid. The shape and size of the single pupil, and the distance between neighbor pupils can be specified. This use case shows how to use the uniformity detector.

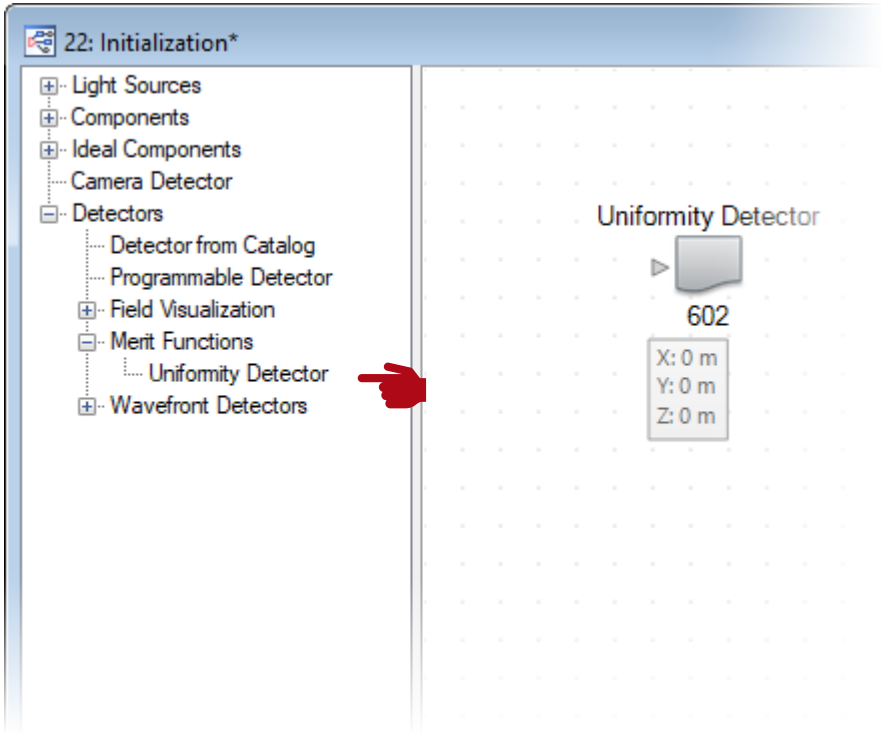
This Use Case Shows ...

- how to use the *Uniformity Detector* within the waveguide toolbox to calculate the uniformity along specified pupils.



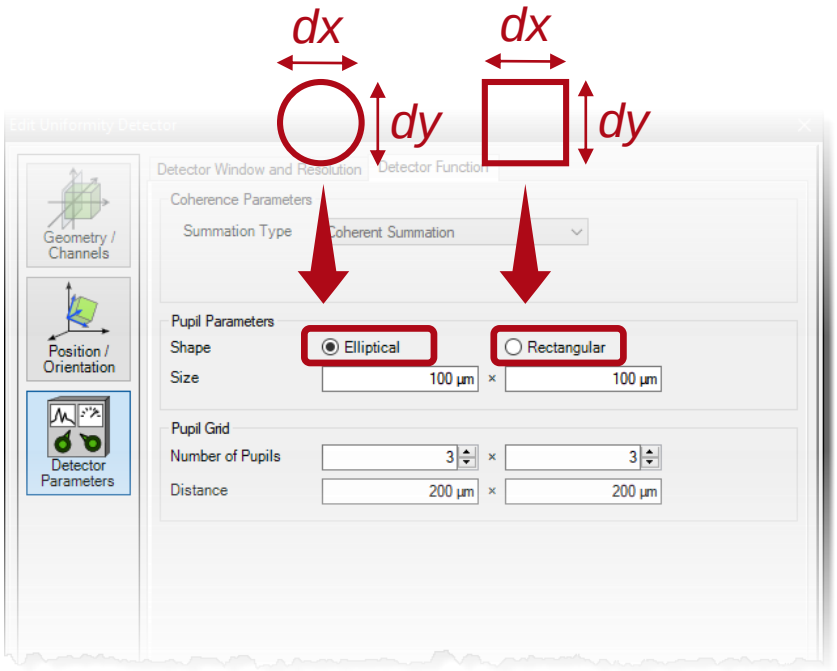
Uniformity Detector Initialization

- The *Uniformity Detector* is only available in the waveguide toolbox.



Pupil Parameters

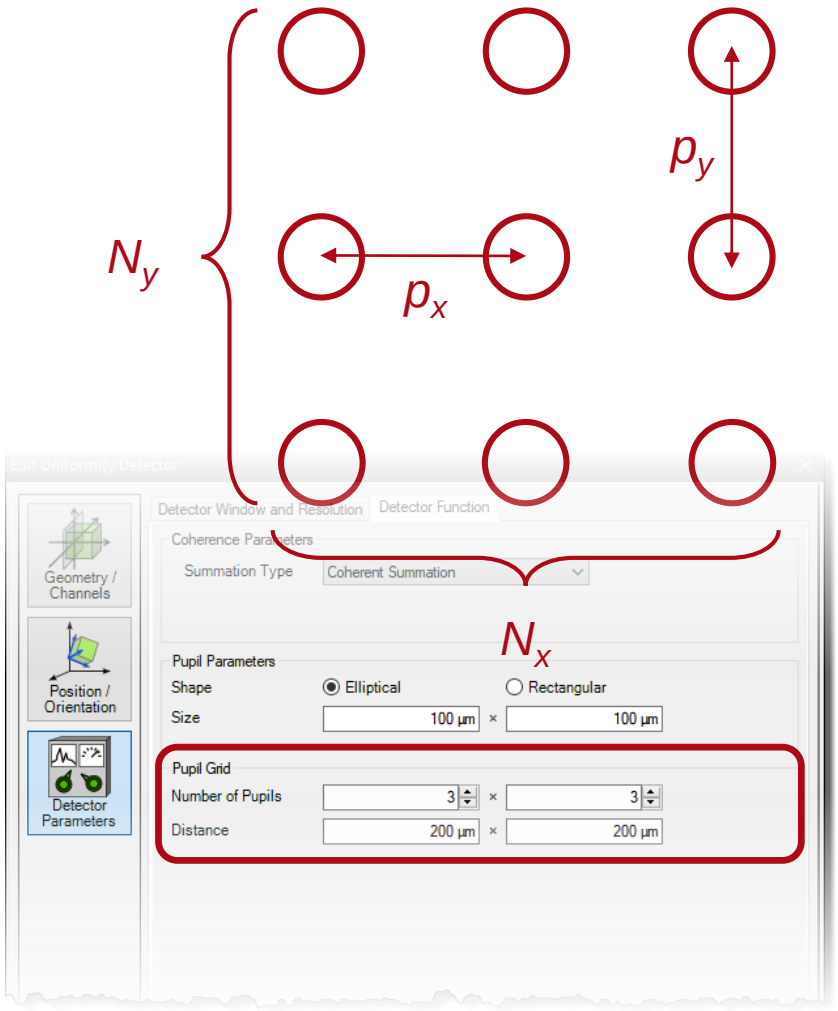
- Each pupil is defined by size (dx × dy) and the shape can be either elliptical or rectangular.



Uniformity Detector Settings

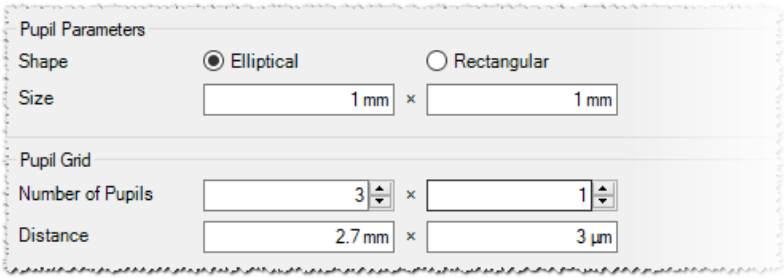
- Each pupil is defined by size (dx × dy) and the shape can be either elliptical or rectangular.

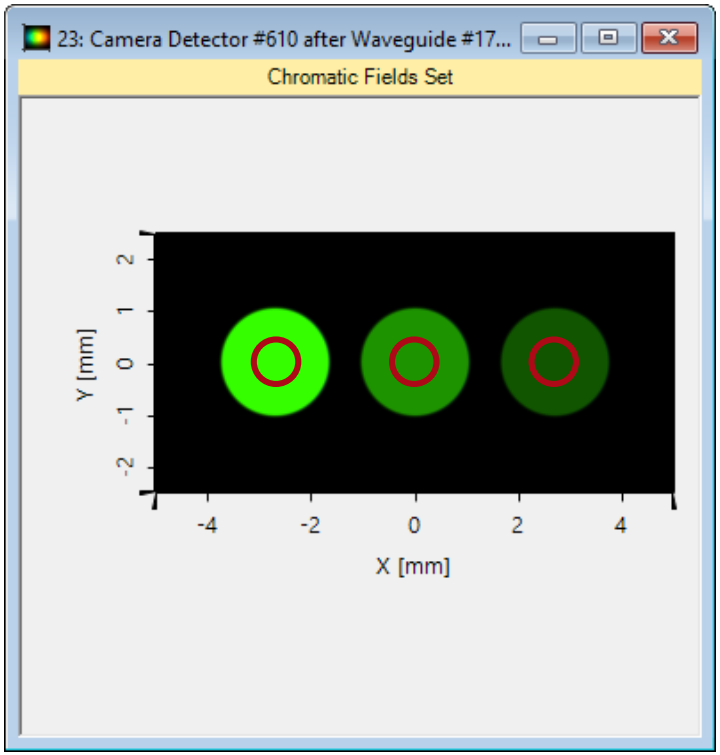
- The defined pupil can be arranged periodically on an equidistant grid specified by the number of pupils $N_x \times N_y$ and a grid distance $p_x \times p_y$.



Example of Pupil Grid: 1D

- Detector setting
  - The pupil grid is arranged symmetrically in the internal coordinate system of the *Uniformity Detector*.

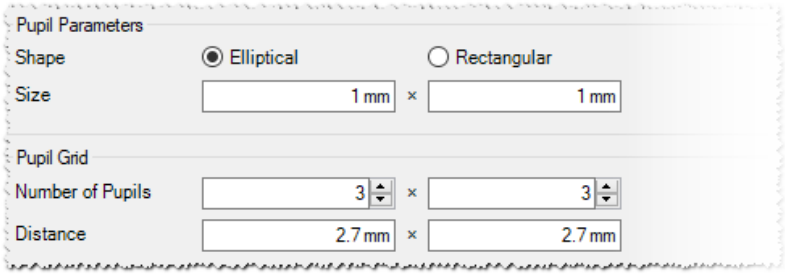


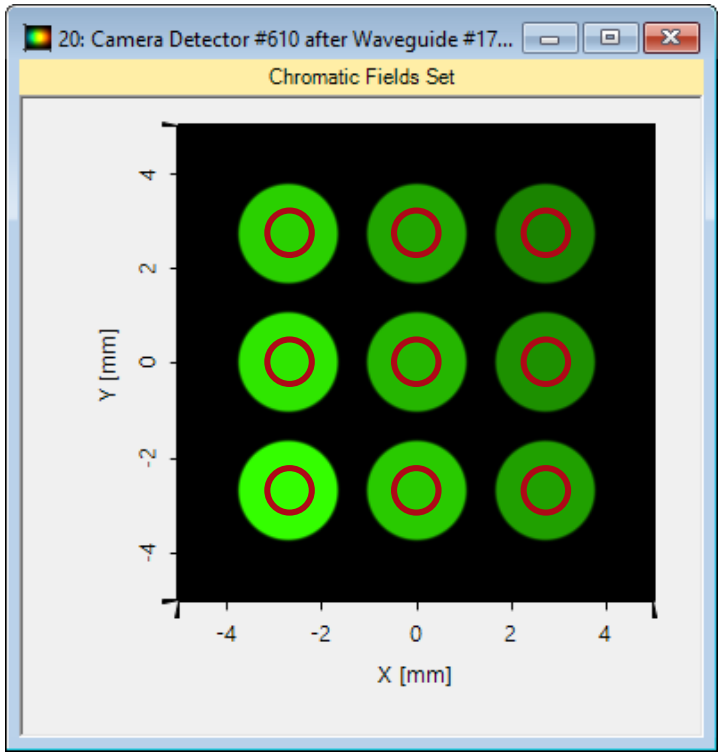


Note: The red circles are just for illustration, while users will not see them in simulation

Example of Pupil Grid: 2D

- Detector setting
  - The pupil grid is arranged symmetrically in the internal coordinate system of the *Uniformity Detector*.





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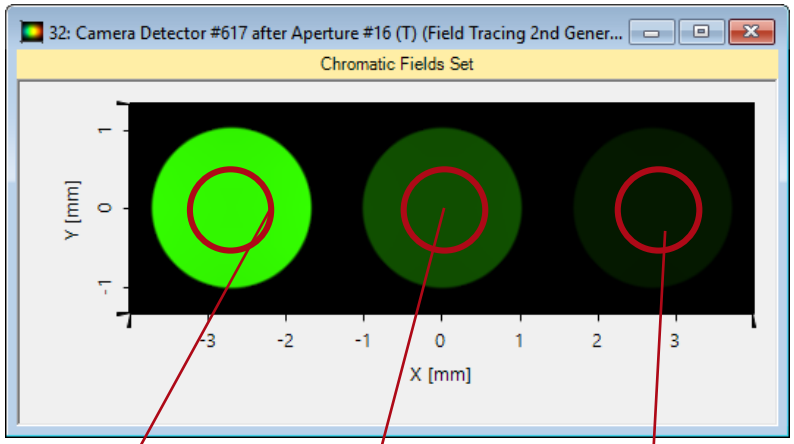
Uniformity Detector Output

- The *Uniformity Detector* provides the following output
  - *arithmetic mean* $\langle I \rangle = \frac{1}{n}\sum_{i=1}^{n} I_i$
  - *standard deviation*

$$\sigma(I) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(I_i - \langle I \rangle)^2}$$

  - *min & max value* $I_{\min} = \min_n(I_n)\ ,\ I_{\max} = \max_n(I_n)$
  - *uniformity error* $\delta(I) = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$



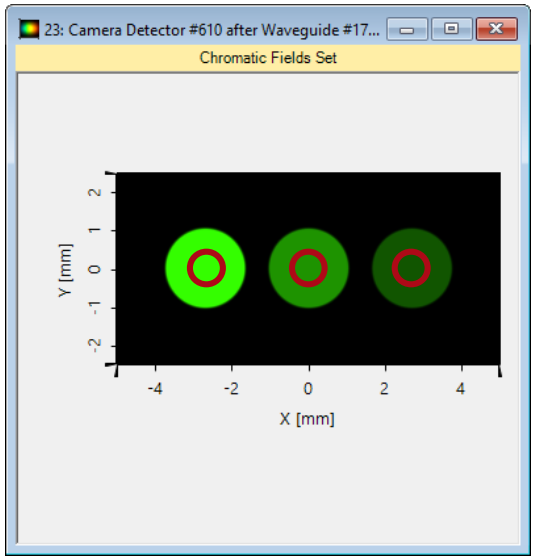
$I_1 = \sum_{\text{region 1}} \text{intensity}$

$I_2 = \sum_{\text{region 2}} \text{intensity}$

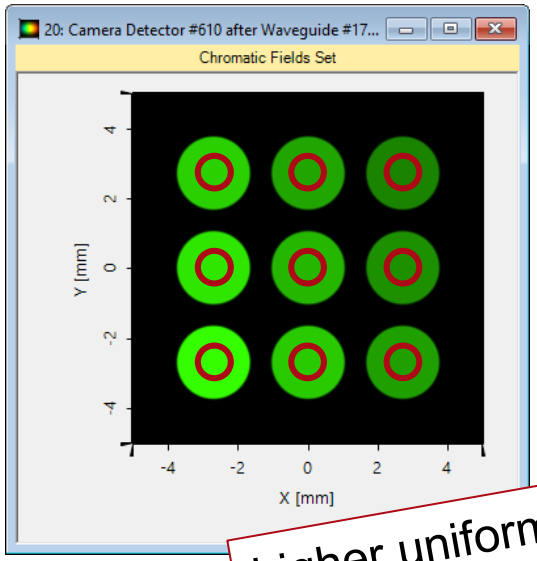
...

$I_n = \sum_{\text{region n}} \text{intensity}$

Examples of Uniformity Detector Output



Parameters	Value & Unit
arithmetic mean $\langle I \rangle$	$0.111\ \mathrm{V^2/m^2}$
standard dev. $\sigma(I)$	$0.162\ \mathrm{V^2/m^2}$
minimum $I_{\min}$	$0.0216\ \mathrm{V^2/m^2}$
maximum $I_{\max}$	$0.240\ \mathrm{V^2/m^2}$
uniformity error $\delta(I)$	83.5 %



higher uniformity

Parameters	Value & Unit
arithmetic mean $\langle I \rangle$	$0.0189\ \mathrm{V^2/m^2}$
standard dev. $\sigma(I)$	$0.0254\ \mathrm{V^2/m^2}$
minimum $I_{\min}$	$0.00818\ \mathrm{V^2/m^2}$
maximum $I_{\max}$	$0.0355\ \mathrm{V^2/m^2}$
uniformity error $\delta(I)$	62.5 %

Document Information

title	Uniformity Detector in the Waveguide Toolbox
version	1.0
VL version used for simulations	7.0.3.4
category	Feature Use Case